Arq Neuropsiquiatr 2000;58(3-B):820-825

SCANNING ELECTRON MICROSCOPY STUDY OF THE CHOROID PLEXUS IN THE MONKEY *(CEBUS APELLA APELLA)*

OISENYL JOSÉ TAMEGA, LUÍS FERNANDO TIRAPELLI**, SIDNEI PETRONI***

ABSTRACT - The cells of the choroid plexus of the lateral ventricles of the monkey *Cebus apella apella* were examined through scanning electron microscopy at contributing to the description of such structures in primates. The animals were anesthetized previously with 3% hypnol intraperitoneally and after perfusion with 2.5% glutaraldehyde, samples of the choroid plexus were collected after exhibition of the central portion and inferior horn of the lateral ventricles. The ventricular surface of those cells presents globose form as well as fine interlaced protrusions named microvilli. Among those, it is observed the presence of some cilia. Resting on the choroid epithelial cells there is a variable number of free cells, with fine prolongations which extend from them. They are probably macrophages and have been compared to Kolmer cells or epiplexus cells, located on choroid epithelium. The choroid plexus of the encephalic lateral ventricles of the monkey *Cebus apella apella* at scanning electron microscopy is similar to that of other primates, as well as to that of other species of mammals mainly cats and rats, and also humans.

KEY WORDS: choroid plexus, monkey, scanning electron microscopy.

Estudo do plexo coróide no macaco (*Cebus apella apella*) ao microscópio eletrônico de varredura

RESUMO - As células do plexo coróide dos ventrículos laterais do macaco-prego (*Cebus apella apella*) foram examinadas ao microscópio eletrônico de varredura com o objetivo de melhor descrever e comparar este órgão ao de outras espécies de mamíferos, principalmente o homem. Inicialmente, os animais foram previamente anestesiados com hipnol a 3% intraperitonealmente e após perfusão com glutaraldeído 2,5%, amostras dos plexos coróides foram coletadas após exibição da porção central e corno inferior dos ventrículos laterais. A superfície ventricular dessas células apresenta forma globosa e a presença de finas protrusões entrelaçadas denominadas microvilosidades. Entre estas, observam-se alguns cílios. Repousando sobre as células epiteliais coróides está presente um número variável de células livres com finos prolongamentos que delas se estendem. São provavelmente macrófagos e têm sido comparadas com as células de Kolmer ou do epiplexo, localizadas sobre o epitélio coróide. O plexo coróide dos ventrículos encefálicos laterais do macaco *Cebus apella apella* ao microscópio eletrônico de varredura é similar ao de outros primatas, assim como de outras espécies de mamíferos, principalmente gatos e ratos, e também de humanos.

PALAVRAS-CHAVE: plexo coróide, macaco, microscópio eletrônico de varredura.

The discovery of the choroid plexus of the encephalic ventricles was attributed by Galeno to Herophilus (335-280 a.C.) who named them “chorioid menix”. Rufos of Ephesus suggested the term “chorioid tunic” to describe the ependyma as the choroid plexus [1]. Later, the choroid plexus was studied at light and electron microscope levels in different animals and by several authors [2-13].

Department of Anatomy, Institute of Biosciences (IB), State University of São Paulo (UNESP): *Postgraduating; **Professor. Aceite 22 maio 2000.

Dr. Oisenyl José Tamega - Department of Anatomy, Institute of Biosciences, UNESP - 18618-000 Rubião Júnior SP - Brasil. FAX 14 821 3744. E-mail: anatomia@ibb.unesp.br

The choroid plexus consists of vascular folds from the piamater externally covered by an epithelium derived from the ependimary coating of the ventricles [12]. Testut & Latarjet [14] refer to the choroid plexus of the lateral ventricles as J-shaped red and granular cords which successively occupy the sphenoidal and frontal portion of the lateral ventricles. More recently, the choroid plexus is histologically described as being formed by small amount of loose connective tissue derived from the piamater and covered by a cubic simple epithelium or a low columnar one originating from the neural tube [15]. Since the last century, several authors (Faivre, 1853; Luschka, 1855; and Claisse & Levi, 1897)[1,4] have attributed to the choroid plexus, among other functions, an outstanding participation in the production of cerebrospinal fluid (CSF) which surrounds the central nervous system. In spite of its important function and although it has been described thoroughly in several species of mammals, the choroid plexus is a structure which has not been studied in primates [16-18].

Thus, the objective of the present investigation was to examine the choroid plexus of the monkey *Cebus apella apella* by scanning electron microscopy for better describe and compare this organ to that of other species of mammals, mainly the human.

METHOD

Three adult male monkey (*Cebus apella apella*), from the Núcleo de Procriação de Primatas of the UNESP Araçatuba Campus, were used. The animals were anesthetized intraperitoneally with 3% hypnol. After perfusion with 2.5% glutaraldehyde, samples of the choroid plexus were collected after craniotomy and exhibition of the central portion and inferior horn of the lateral ventricles.

These structures were washed in 0.2 M sodium phosphate solution, pH 7.4 and immersed in 2.5% glutaraldehyde. After being fixed for 24 hours at room temperature, the samples were washed in 0.1 M sodium phosphate solution, pH 7.3. Afterwards they were post-fixed in 1% osmic tetroxide solution, for one hour in the same solution and again washed in phosphate solution. The dehydration was conducted in growing levels of ethanol, starting from 75% up to the absolute. The drying of the pieces was done by a Balzers CPD-020 critical point apparatus, using dioxide of liquid carbon. Afterwards they were mounted in metallic bases with silver glue covered with 10 nm of gold in Balzers MED-010 apparatus and examined in scanning electron microscopy SEM 515-Philips, under 15 Kv tension at the Center of Electronic Microscopy of IB/UNESP.

RESULTS

The surface of the choroid plexus of the lateral ventricles at low magnification is constituted by folds or crests in a kind of parallel way (Figs 1 and 2). These folds have varied dimensions, and at scanning electron microscopy, the surface shows apparently homogeneous projections similar to vesicles, each one representing a choroid cell (Figs 1 and 2). The diameter of the cells varies between 7 and 11 µm.

The areas that surround each one of the cellular projections are deeper and electron-dense (Figs 3 and 4), corresponding to junction sites among the adjacent choroid cells through luminal surface of its lateral walls which at this place are united by a junctional complex.

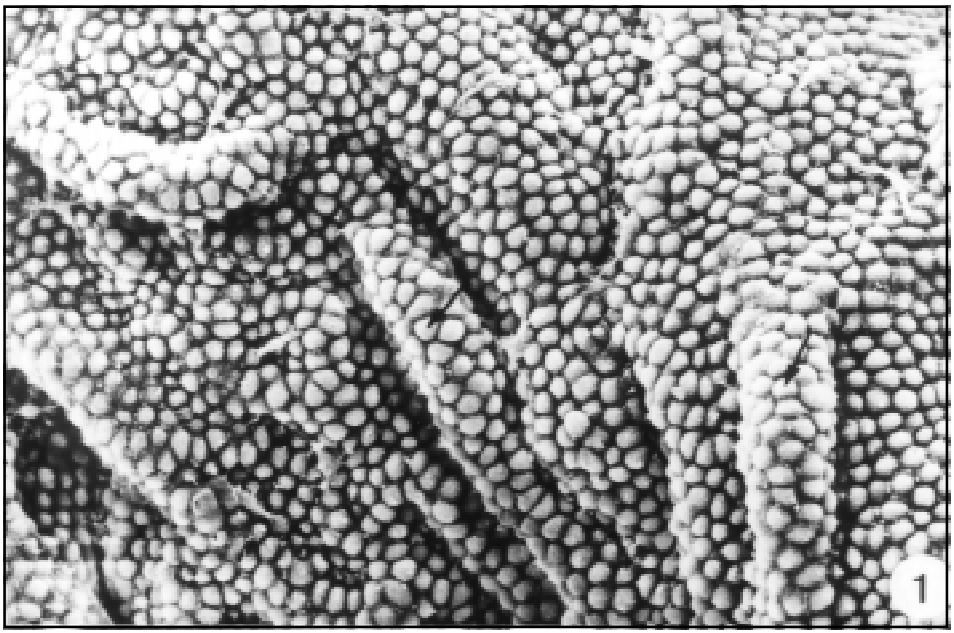
At higher magnification, it is visible at the surface of each epithelial choroid cells the presence of a tangling of fine and irregular projections named microvilli (Figs 3 and 4). It is observed some cilia among those (Fig 3).

It was observed the presence of cells close to the luminal surface of choroid epithelium. These prolonged cells present cytoplasmatic prolongations similar to the expansions of the perikaryon and are observed indented to the microvilli of the ependimary cellular surface. Firstly described by Kolmer (1921), they were named “cells of the epiplexus” or “Kolmer cells” (Figs 2, 5 and 6).

DISCUSSION

The choroid plexus of the encephalic lateral ventricles of the monkey *Cebus apella apella* at scanning electron microscopy is similar to that in other primates [18], as well as to that in other species of mammals mainly cats [9,16] and rats [11], and also humans [12].

According to the diameter of the choroid cells, similar values found in our study were also reported in the choroid plexus of the lateral ventricles of rats [11].



Figs 1 and 2. Choroid plexus of the lateral ventricles showing a series of longitudinal folds with variable extensions. Its surface shows spherical protrusions that correspond to the choroid cells (arrows). Notice the presence of free cells resting at the surface of the choroid epithelium (k). 74x; 106x.

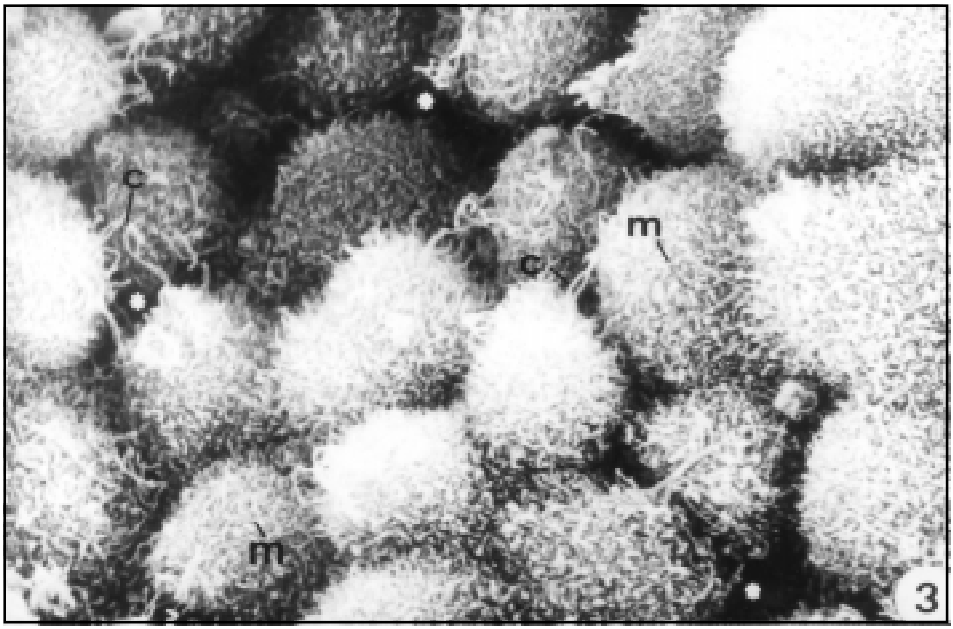


Fig 3. Surface of the choroid cells in a larger increase. Each cell is projected in the luminal surface in domed form, presenting some cilia (c) and a great number of fine microvilli (m). Electron-dense areas corresponding to the junction places among the choroid cells (*). 682x.

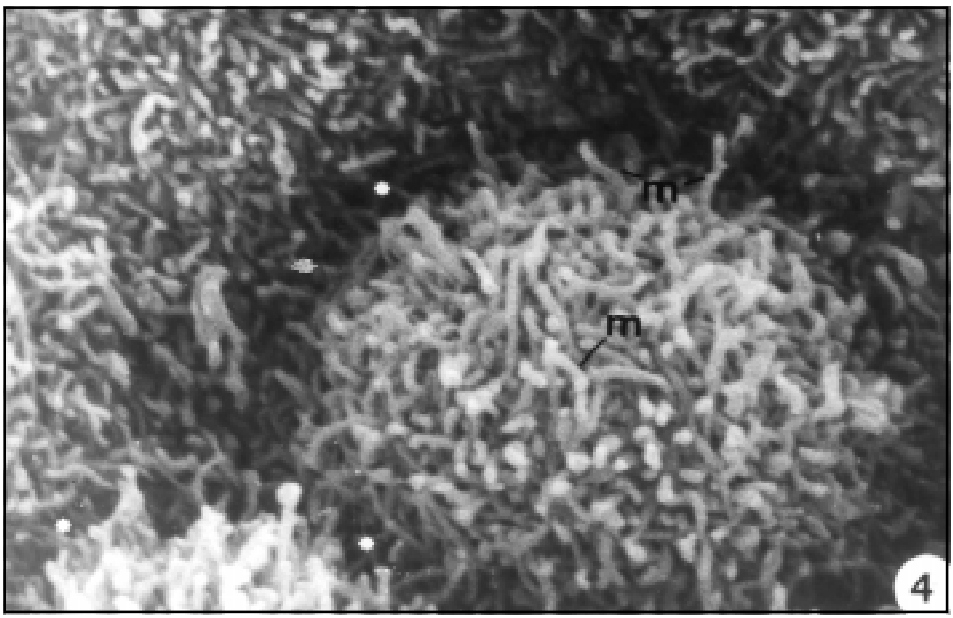
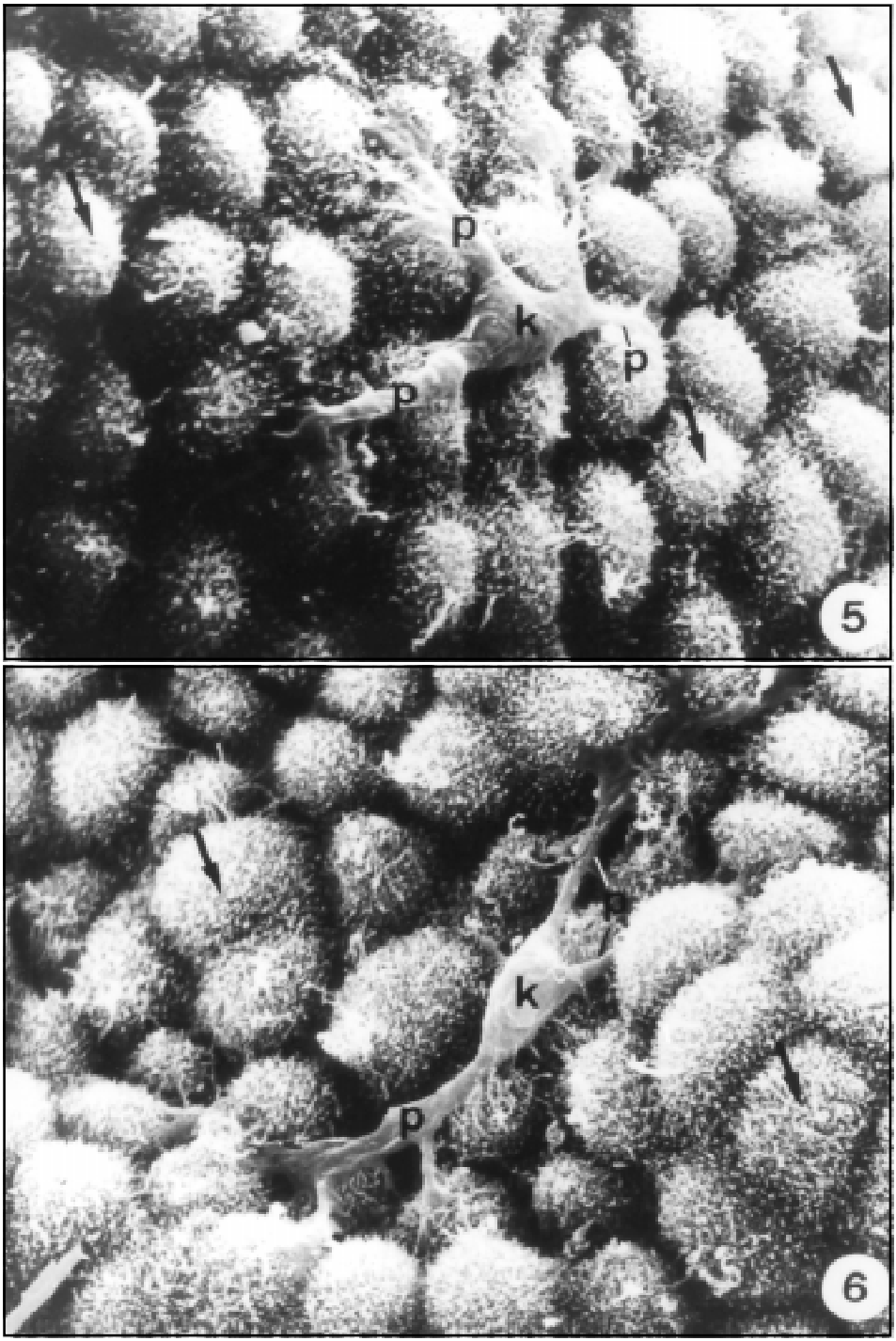


Fig 4. Details of a cell of the choroid epithelium. Electron-dense areas corresponding to the junction places among the choroid cells (*). Microvilli (m). 2304x.



Figs 5 and 6. Free cells of Kolmer (k) resting at the surface of the choroid epithelium. Notice the presence of fine cytoplasmatic prolongations (p) extending from its body. Choroid cells (arrows). 405x; 425x.

The microvilli and the presence of some cilia described in this species could also be observed in rats[11] and in humans [12]. These fine and irregular microvilli show their importance in the increase of the surface area of the cell, an important factor for their secretory activity, as well as other cellular characteristics.

However, the presence of cells with different appearance was described [11] which, instead of fine and long protrusions, were more swollen and with a foamy surface. Such cells could not be observed in this study.

Reported as leukocytes which infiltrate in the lateral ventricles, Kolmer cells still have their origin being contested by several authors [7,11,17-19]. Those cells have their origin from cell elements of the estroma of connective tissue [19,20]. Carpenter et al. [16] proposed that monocytes crossed the choroid blood vessels and then penetrate in the space of connective tissue, being then macrophages and consequently crossed the choroid epithelium to become "epiplexus cells".

In studies under electron microscopy scanning was observed [16,17] such cells resting in the microvilli of the choroid cells and sometimes showing their surface indented by the projections of the microvilli and cilia of those cells.

Studies about choroid plexus show that the "epiplexus cells" have their origin from monocytes[16,18]. This suggests the same origin for the "epiplexus cells" of the monkey, due to the presented morphologic similarity.

Studies in rats[21] suggest that the "epiplexus cells" along with lysosomal activity of these choroid epithelial cells act as a protection and defense line, helped yet by the blood-CSF barrier.

REFERENCES

1. Dohrmann GJ. The choroid plexus: a historical review. Brain Res 1970;18:197-218.
2. Meek WJ. Study of the choroid plexus. J Comp Neurol Psychol 1907;17:286-306.
3. Agduhr E. Choroid plexus and ependyma. In Cytology of the nervous system. Upsala Sect 1932;11:537-573.
4. Zimman L. Investigaciones sobre la estructura de los plexos coroideos en estado normal y patológico. Arch Histol 1943;1:277-328.
5. Maxwell DS, Pease DC. The electron microscopy study of the choroid plexus. J Biophys Biochem Cytol 1956;2:467-474.
6. Millen JW, Rogers GE. An electron microscopy study of the choroid plexus in the rabbit. J Biophys Biochem Cytol 1956;2:407-416.
7. Tennyson VM, Pappas GD. Fine structure of the developing telencephalic and myelencephalic choroid plexus in the rat. J Comp Neurol 1964;123:379-412.
8. Cancilla PA, Zimmerman HM, Becker NH. A histochemical and fine structure study of the developing rat choroid plexus. Acta Neuropathol 1965;6:188-200.
9. Carpenter SJ. An electron microscopy study of the choroid plexus of Necturus maculosus. J Com Neurol 1966;127:413-434.
10. Shuangshoti S, Netsky MG. Histogenesis of choroid plexus in man. Am J Anat 1966;118:283-316.
11. Peters A. The surface fine structure of the choroid plexus and ependymal lining of the rat lateral ventricle. J Neurocytol 1974;3:99-108.
12. Webster HF. Choroid plexus. In Peters A, Palay SL, Webster HF. The fine structure of the nervous system: the neurons and supporting cells. Philadelphia: Saunders, 1976: 280-294.
13. Spector R, Johanson CE. Plexos coroideos de los mamíferos. Invest Cienc 1989;226:44-51.
14. Testut L, Latarjet A. Tratado de anatomia humana. Barcelona: Salvat, 1990.
15. Junqueira LCU, Carneiro J. Histologia básica. 8.Ed. Rio de Janeiro: Guanabara Koogan, 1995.
16. Carpenter SJ, McCarthy LE, Borison NL. Electron microscopic study of the epiplexus (Kolmer) cells of the cat choroid plexus. Z Zellforsch Mikrosk Anat 1970;110:471-486.
17. Hoyosa Y, Fujita T. Scanning electron microscope observations on intraventricular macrophages (Kolmer cells) in the rat brain. Arch Histol Jpn 1973;35:133-140.
18. Ling EA. Ultrastructure and mode of formating of epiplexus cells in the choroid plexus in the lateral ventricles of the monkey (Macaca fasciculares). J Anat 1981;133:555-569.
19. Biond G. Zur Histopathologie des menschlichen Plexus choroideus und des Ependyme. Arch Psychiat Nervenkr 1934;101:666-728.
20. Ariens-Kappers J. Structural and funtional changes in the telencephalic choroid plexus during human ontogenesis. In CIBA Foundation Symposium on the Cerebrospinal Fluid 1958: 3-31.
21. Lu J, Laur C, Ling EA. Intraventricular macrophages in the lateral ventricles with special reference to epiplexus cells: a quantitative analysis and their uptake of fluorescent tracer injected intraperitoneally in rats of different age. J Anat 1993;183:405-414.